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# Personal Protective Equipment Supply Chain: Lessons Learned from Recent Public Health Emergency Responses

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Personal protective equipment (PPE) that protects healthcare workers from infection is a critical component of infection control strategies in healthcare settings. During a public health emergency response, protecting healthcare workers from infectious disease is essential, given that they provide clinical care to those who fall ill, have a high risk of exposure, and need to be assured of occupational safety. Like most goods in the United States, the PPE market supply is based on demand. The US PPE supply chain has minimal ability to rapidly surge production, resulting in challenges to meeting large unexpected increases in demand that might occur during a public health emergency. Additionally, a significant proportion of the supply chain is produced offshore and might not be available to the US market during an emergency because of export restrictions or nationalization of manufacturing facilities. Efforts to increase supplies during previous public health emergencies have been challenging. During the 2009 H1N1 influenza pandemic and the 2014 Ebola virus epidemic, the commercial supply chain of pharmaceutical and healthcare products quickly became critical response components. This article reviews lessons learned from these responses from a PPE supply chain and systems perspective and examines ways to improve PPE readiness for future responses.

**Keywords:** Personal protective equipment, Supply chain, Pandemic influenza, Ebola, Public health preparedness/response

Personal protective equipment (PPE) for healthcare workers has gained significant attention in planning for future public health emergencies because PPE is a critical component of infection control strategies in healthcare settings.[1] Personal protective equipment includes protective clothing and other equipment designed to protect healthcare workers from injury or infection. Respiratory protective devices are of particular importance in a public health

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response to an infectious disease that spreads from person to person through the respiratory route (eg, a pandemic influenza virus). In this situation, protection of healthcare workers from respiratory transmission of infectious disease is essential, given that they provide clinical care to those who fall ill, have a high risk of exposure, and need to be assured of occupational safety. Personal protective equipment to protect healthcare workers from a disease transmitted through the respiratory route includes both respiratory protective devices (N95 filtering facepiece respirators or personal powered air purifying respirators) and surgical masks to place on ill patients to decrease the risk of respiratory transmission (source control).[2] Like most goods supplied in the United States, the supply of PPE in the market is based on demand. The US PPE supply chain provides sufficient product to meet anticipated normal market demands with minimal ability to immediately surge production,[3] resulting in challenges in meeting large, unexpected increases in demand that might occur during a public health response.[4-6] For example, routine annual production in the United States has been estimated to be 1.5 billion N95 respirators and 3.6 billion surgical masks, whereas a recent assessment estimated that 1.7 to 3.5 billion N95 respirators and 0.1 to 0.4 billion surgical masks would be needed to protect healthcare workers in the event of a severe influenza pandemic.[7] Other daily routine use of these products in health care and in other industries may place additional demands on these supplies. A significant proportion of the respiratory protective device supply chain is produced offshore and may not be available to the US market during a public health response because of export restrictions to the United States or the nationalization of manufacturing facilities, which may favor in-country rather than foreign demands.[8]

Recent response experience shows that efforts to increase supplies during a public health emergency, in the absence of advanced planning, are challenging. During the public health responses to the 2009 H1N1 influenza pandemic and the 2014 Ebola virus epidemic, the commercial supply chain, which included manufacturers, distributors, and end users (pharmacies/hospitals) of pharmaceutical and healthcare products, were critical to the response. This article analyzes key lessons learned from these responses from a PPE supply chain and systems perspective and takes a closer look at considerations to improve PPE readiness for future responses.

## 2009 H1N1 Influenza Response

### *Background*

The Centers for Disease Control and Prevention's (CDC) Strategic National Stockpile (SNS) is the largest national repository of pharmaceuticals and medical supplies that can be used to support a public health emergency. The government does not typically intervene with the normal supply chain during nonemergency times. However, if a response is great enough to cause local supplies to become depleted, products from the SNS may be deployed.[9] Stockpiling PPE for an incident like an influenza pandemic—which, by definition, happens on an international scale, may affect the whole country at the same time, and will have a prolonged duration—presents different circumstances than a regional or local emergency (eg, an anthrax attack), in which products can be shifted to where they are needed around the country to fill gaps in supply. In 2006, as directed by the National Strategy for Pandemic Influenza and through supplemental funding for influenza preparedness, PPE was purchased for CDC's SNS (104 million N95 filtering facepiece respirators and 52 million facemasks);[10] the goal of this purchase was to begin to address the large estimated gap, with a focus on healthcare workers as end users.[11] Decisions on what PPE to purchase were based on need for protection, funding, and availability of products on the market that could immediately increase US readiness.[12]

In April 2009, at the beginning of the 2009 H1N1 influenza pandemic, the demand for N95 filtering facepiece respirators (hereafter referred to as N95 respirators) and facemasks in the United States spiked dramatically. Facilities were ordering N95 respirators and facemasks in quantities that exceeded current supply, resulting in a 2- to 3-year backlog and causing market shortages of specific N95 respirators.[4,5,13-15] CDC engaged in discussions with supply chain partners, including major distributors of N95 respirators and facemasks, manufacturers, and professional organizations (eg, the International Safety Equipment Association [ISEA] and the Healthcare Industry Distributors Association), to better understand supply and demand dynamics. It became evident that the supply chain (manufacturing, distribution, and ordering) for respiratory protective devices and other PPE was complex, involving numerous manufacturers and distributors.

To reduce potential shortages, 75% of N95 respirators and 25% of facemasks contained in the CDC's SNS ($\sim$100 million products) were deployed for use in healthcare settings over the course of the 2009 H1N1 pandemic response.[16] Products were provided to state health departments, which were then responsible for distributing them to facilities in their jurisdictions that needed them. Simultaneously, manufacturers increased production of products to meet the increases in demand.[17]

### *Understanding Demand and Supply*

A major difficulty during the response to 2009 H1N1 influenza was being able to project supply and demand for N95 respirators and facemasks because of the uncertainty of the pandemic and the complexity of the supply chain system.[14] Hospitals and frontline care facilities ordered products in much larger quantities than was needed for

patient care at the time to support anticipated increased usage and built-up caches of supplies to prepare for a possible increase in pandemic severity.[5]

With the significant spike in product demand, healthcare product distributors were unable to fill all orders. Distributors filled customer orders using various allocation strategies, such as filling orders in percentages based on previous years' orders, or providing products to entities serving hospital networks to allow for resource sharing. In response to receiving partial orders or getting delayed delivery timeframes extended from 2 to 10 weeks, some facilities placed orders with multiple vendors, hoping to get a percentage of each order filled to increase their facility's inventory. Since no centralized order monitoring system existed in the supply chain, these practices were difficult to monitor.[18-20] Without a system-wide mechanism to track the amount of product being used to support patient care and healthcare worker protection, and to track the amount of product ordered to support future preparedness in each facility, appropriate allocation and distribution of product was challenging for the commercial sector. In addition, manufacturers filling distributor orders had limited knowledge of whether the orders placed were duplicative, and, without knowing what true demand looked like and what sustained demand was projected to be, increasing manufacturing capacity came with a risk that products produced for pending orders might not be purchased and some orders that had been placed might be cancelled.

To further complicate the demand picture, it was not known how long the pandemic would last and if the severity of the pandemic would change; manufacturers could only speculate as to how long the increased demand would continue.

Understanding supply was also a challenge in the 2009 H1N1 response. Market production and surge capacity information were not readily available to the public or to the government. Basic questions to inform the response could not be answered at the federal level without extrapolation of data and use of major assumptions, including each manufacturer's baseline level of market production and surge capacity and whether raw material shortages might present a concern if production was increased. By fostering partnerships with industry, the federal government was able to ascertain some data from select manufacturers, but with the competitiveness of the marketplace and proprietary nature of the information requested, it was difficult to gather the information needed to make informed decisions and to know where the federal government could assist.

Another major supply concern related to the US reliance on foreign markets (eg, Mexico and China) for N95 respirators for either raw material or finished products. This reliance on foreign suppliers raised several issues, including whether suppliers or their governments might stop exportation of raw material or finished products to fulfill their own country's requirements. Therefore, the reliance on imported materials also presented additional supply chain security concerns.[21]

### *Facilities and Product Use*

During the 2009 H1N1 pandemic, as an important component of infection control strategy, CDC recommended respiratory protective devices for healthcare workers including first responders when "caring for persons with known, probable or suspected 2009 H1N1 [infection] or influenza-like illness (ILI)."[22,23] Upon release of these recommendations, it became apparent that limited supplies could make the recommendations difficult to implement. Although the release of N95 respirators and facemasks from the federal SNS increased facility inventory levels, products received were not necessarily the items on which hospital staff were trained and fit tested, posing additional challenges.

Product use was also affected by regulatory requirements. During the 2009 H1N1 response, the FDA granted an Emergency Use Authorization (EUA) to allow select non-FDA cleared N95 respirators to be used in a healthcare setting (under nonpandemic circumstances, respirators used in the healthcare settings are required to be cleared by the FDA).[24] The EUA applied only to products released from the SNS and did not cover the use of all N95 filtering face piece respirators.[14] Extended use or reuse of N95 respirators was sometimes considered by healthcare workers when product supplies became limited,[25] but federal guidelines for extended use and reuse had not yet been developed,[20] and end-user acceptability for alternative guidance had not been evaluated.[26]

## 2014 Ebola Response

### *Background*

As with pandemic influenza, appropriate use of PPE is an important component in the protection of healthcare workers caring for patients with Ebola virus disease, as part of an infection control strategy that includes early detection and prevention of exposure, implementation of administrative controls, and facilitation of engineering and environmental controls.[1] However, unlike the PPE needed by healthcare workers to care for patients with pandemic influenza, extensive, full-coverage PPE is recommended when caring for a patient with suspected or confirmed Ebola virus disease, since the virus can be spread to others through direct contact with broken skin or mucous membranes, infected blood, or body fluids.

In October 2014, CDC, in collaboration with its partners, released updated draft guidance on use of PPE for healthcare workers caring for patients under investigation for or confirmed to have Ebola virus disease.[27] The PPE

guidance included a list of more than 15 possible types of products that could be used by healthcare workers when caring for Ebola patients and included multiple combinations of PPE for consideration, including N95 respirators and personal powered air purifying respirators. The publication of these recommendations immediately began to affect availability of US commercial supplies.[28]

The goal at the hospital level was to increase readiness to care for patients under investigation for or with confirmed Ebola virus disease. Depending on the patient's severity of illness, the average time to care for an Ebola patient ranged from 20 to 40 days; thus, large volumes of supplies would be needed to protect members of the healthcare team caring for a single Ebola patient.[29] In addition, given the specific donning and doffing processes needed, training the staff on PPE use was mandatory, which required additional supplies. To further complicate the situation, the PPE guidance outlined recommendations for some products that were commonly used (eg, gloves and gowns), while other recommended products were not normally held in hospitals and were more commonly found in the chemical industry (eg, coveralls and boot covers), resulting in facilities needing to establish purchasing arrangements with nontraditional vendors because their normal suppliers did not carry all the recommended PPE.

The multidisciplinary healthcare teams caring for patients ranged in number across hospitals, and members of a team required different variations of PPE depending on their role and interaction with the patient. A 16-person healthcare team caring for a single patient for 20 days would require a hospital to have an estimated 320 hoods for personal powered air purifying respirators and 320 coveralls.[30] At the onset of the response, many hospitals reported having only a 0- to 3-day (0-48 hoods/coveralls) supply of these products. Large quantities of products, which may have been part of routine hospital inventory, were needed to support healthcare worker training and patient care, should a patient with suspected Ebola require evaluation. PPE considerations were a major concern in hospitals during the Ebola response; in a survey of infection prevention experts, issues related to PPE were the most commonly listed challenge (listed as their "biggest challenge" by 37% of respondents), with obtaining PPE, training healthcare workers, and managing changing guidelines as the 3 greatest challenges related to PPE.[31]

## *Improving Demand and Supply Equilibrium*

In October 2014, within 2 weeks of the release of the updated CDC PPE guidance, manufacturers of products referenced in the guidance reported customer order increases ranging from 10 to 200 times normal, depending on the product.[32] Although increased supplies were needed to meet these demands, the uncertainty about how long the response would last and how much product would be needed posed challenges in determining manufacturing and the degree of surge capacity that was required. Despite the absence of clear sustained demand, some manufacturers began to increase manufacturing and reported to the federal government that they were increasing production of PPE products. The time needed to ramp up supplies and fill orders depended on the product and manufacturer. Most products, even those in short supply, were made available in smaller quantities than requested or with later delivery dates, and distributors worked to implement allocation and prioritization strategies to best address customer needs.[33] In contrast to the 2009 H1N1 response, the number of patients being treated for Ebola in the United States was small. Manufacturers and distributors were aware that the majority of product being ordered was for preparedness efforts, training purposes, or to support the evaluation of patients under investigation.

With the dramatic increase nationwide in hospital orders, it quickly became apparent that additional guidance for healthcare facilities was needed. In December 2014, CDC guidance was released that introduced a concept to help ensure that the level of preparedness in healthcare facilities was consistent with a facility's role in a tiered strategy.[34] In this tiered approach, hospitals were categorized as frontline facilities, assessment hospitals, or Ebola treatment centers. Each tier required different types and amounts of PPE supplies (ie, sufficient supplies to care for 1 patient for <24 hours, 4-5 days, and 7 days for frontline facilities, assessment hospitals, and Ebola treatment centers, respectively).[33] This tiered strategy allowed a better understanding of how much product was needed based on a facility's role and helped suppliers better understand how to prioritize and fill orders. The supply recommendations included in the tiered strategy assumed the ability of the supply chain to pivot and be redirected if a case presented and additional supplies were needed. In addition, CDC provided guidance regarding strategies for healthcare facilities to acquire adequate supplies of PPE for Ebola preparedness.[33] As part of the national response effort, CDC was able to respond to multiple state and facility inquiries in which a patient under investigation presented and additional supplies were needed; working with industry partners, supplies were redirected to those facilities.[9,32,33] Redirection of supplies for the Ebola response to respond to immediate needs proved to be a viable short-term option for this response, but it may not be as feasible or the best option in future responses with more widespread impact.

## *Facilities and Product Use*

As hospitals placed orders, manufacturers and distributors were able to identify alternatives for some product lines to meet customer needs; however, healthcare facilities were

reluctant to shift from brands and models that staff were already trained in using. Staff had spent training hours practicing donning and doffing protocols and becoming familiar with specific PPE products. The combination of products recommended for protection was more complex than normal standards of practice.[35] Facility preferences and protocols on products, models, and/or brands, coupled with lack of interoperability across products (eg, the hood for one model of personal powered air purifying respirator could not be used with the blower unit of another) further complicated PPE supply issues. Pressure from some hospital staff to use certain types of products might have made it challenging for facilities to use alternative products (eg, changing PAPR models or shifting from powered air purifying respirators to N95 respirators was seen as lowering standards), further exacerbating the demand on select product lines.[36]

Sharing of supplies also became critical as hospitals and states improved readiness. Efforts to coordinate supplies across hospitals, coalitions, and state stockpiles were encouraged by the federal government.[33] Partnering with other facilities and attempting to use similar products provided opportunities for other hospitals, coalitions, and stockpiles in a community to be sources of product backfill in instances when supplies were running low or when there were delays in deliveries of commercial supplies.

Finally, this response highlighted a challenge related to ordering products listed in the CDC PPE guidance. PPE selection requires an understanding of standards and product labeling, which varies between products and does not always include terminology to identify if products were appropriate for use as described in the guidance. For example, determining if a product was fluid resistant or impermeable, if it met certain reference standards (eg, International Organization for Standardization or Association for the Advancement of Medical Instrumentation standards), or knowing what its shelf life was required calls to distributors and manufacturers or internet searches, since information was not on the product labels. In response to this, some of the manufacturers immediately improved communication and marketing of products.[37] In addition, after recognizing the complexities of product ordering to meet its PPE recommendations, the CDC developed a tool to aid in product selection.[38]

## Strategies for Improvement

Based on these recent experiences, multiple strategies should be considered to improve use and acquisition of PPE during a public health emergency and to assist the supply chain entities to make informed decisions during limited supply/high demand situations to benefit the overall public health response. We provide possible strategies to be explored by industry, government, and the healthcare sector to advance PPE preparedness.

- *Conduct facility training and, when feasible, implement strategies for filtering facepiece respirator use that increase options during a future emergency*—To mitigate the potential for shortages of N95 respirators, if feasible, facilities may consider training on more than one model of respirator during regular business operations. Having staff familiar and fit tested on various product lines will allow the ability to shift to different product models more easily if needed during a response. To the extent possible, facilities should also consider pre-identifying those who are considered to be the likely staff to have a very high or high risk of exposure (eg, those performing aerosol-generating procedures on known or suspected patients that are infected by the pathogen of concern, or key healthcare delivery and support staff more likely to be exposed to known or suspected patients infected by the pathogen of concern) during a public health emergency and adjust product use accordingly (see control banding below). Facility preparedness plans should also consider limiting elective procedures at times when PPE shortages are of major concern to reduce the number of products needed during a response.
- *Improve guidance: Include standards on products and guidance on how much of each product might be needed during a response*—Standards state the level of protection a product provides against a certain hazard. Workers are more likely to use PPE when they are confident that the equipment will provide them with adequate protection and conform to applicable standards. Both during public health emergencies and under routine conditions, the guidance identifying PPE required for use should include standards to clarify the level of protection an end-user should expect. In addition, the earlier public health officials can provide guidance on the standards to which products should conform, and estimates on how much of a product a facility should have, the more informed product ordering will be. Clear guidance for product use that is agreed on across federal partners and realistic to implement (ie, products are available and supply has had a chance to surge to meet increased need) would help define what products should be ordered. If recommendations are introducing new or different standards of care or regulatory considerations, these should be socialized and assessed for acceptability by healthcare workers, unions, and federal and state regulators in advance of an event. Before releasing guidance, the availability of products that conform to standards identified to implement guidance should also be considered. If products specified in the guidance might be difficult to acquire during an event, then acceptable alternatives should be specified. At a minimum, advance notice of forthcoming guidance of this type should be provided to appropriate manufacturers and their trade groups so the effect on supply chain dynamics can be assessed.

- *Monitor PPE use and distribution*—PPE purchase, use, and distribution in the healthcare system needs to be monitored to ensure the effective delivery of patient care during an emergency response. Recognizing this need, the CDC is supporting the development of a system to monitor PPE supply, use, and distribution to anticipate potential PPE supply shortfalls and distribution needs in a systematic way. This system will minimize inappropriate purchases and improve overall PPE distribution across the healthcare system. A critical component to the success of the system is for various hospital staff responsible for PPE ordering to be trained on how to use it. The system is under development now and expected to be operationalized in 15 to 20 hospitals by 2018. Sustainability of this system is critical to effectively monitor PPE use and distribution and react to needs on a national level.[39]
- *Establish or centralize visibility on orders placed*—Central visibility on orders placed for PPE would allow distributors and manufacturers to better identify duplicate orders and project true product demand to inform manufacturing surge. Understanding true demand and assessing if supplies are available to meet that demand would also better inform release of public health stockpiles or the need for alternative guidance for situations when the recommended PPE might not be available, help to facilitate redistribution, and support local decision making regarding PPE distribution. Coordination and prioritization of federal purchases (eg, Veteran's Administration, Department of Homeland Security, Department of Health and Human Services, Department of Defense, etc) are also needed and would allow the US government to better plan acquisitions so as not to unnecessarily burden an already stressed market or, optimally, to stimulate market response appropriately through large volume orders that could decrease the risk for manufacturers to increase production.
- *Share supplies*—Facilities within a community and jurisdictions should be encouraged to have plans in place to share products during an emergency. For products that require special training or fit testing, it may also be beneficial for neighboring facilities to use the same products to eliminate the need for just-in-time training when different products are shared. Facilities that choose to coordinate purchases with other facilities might qualify for volume-based discounts from vendors. The federal government should also consider similar plans during an event to share supplies as practicable.
- *Improve just-in-time supply system and share responsibility*—The healthcare supply chain in the United States is designed for efficiency and is built to have very little excess inventory. Although this model is beneficial from a business standpoint, mechanisms to encourage the supply chain to have elasticity in the system to allow for increased supply in response to increases in demand need to be explored. This additional capacity could be held in stockpiles, either in healthcare facilities, at the distributor level, at the manufacturer level, or by federal and/or state public health agencies. In the National Strategy for Pandemic Influenza, it was recognized "that preparing for and responding to a pandemic cannot be viewed as a purely federal responsibility, and that the nation must have a system of plans at all levels of government and in all sectors outside of government that can be integrated to address the pandemic threat."[9] Because of the large amount of PPE that could be needed during a public health emergency, federal resources such as the CDC's SNS cannot be relied on as a sole source for providing PPE countermeasures for the entire nation. Ideally, SNS PPE supplies should be an integrated supply source that can flow seamlessly into the facilities' supply chains if problems and concerns confronted in previous responses are to be avoided. Stockpiles (federal, regional, and state) should be designed to address acute outbreak demands and to provide PPE at a time during which production capacity can be increased to meet needs. Ideally, a strategic plan that incorporates stockpiles and the commercial system should be considered to create a solution that includes multiple layers and various products to bolster the entire system. Stockpiling solutions and overall strategies should consider various products, determine quantity of product needed, consider magnitude of storage space needed, and determine shelf life, the ability to rotate products so that inventories remain relevant and reflect the products most used by end-users and changes in technologies, and replacement costs. In addition, acquisition strategies for stockpiles held at various levels (facilities/hospital systems, distributors) could include stockpiling a percentage of product needed over time. For example, for products that have a 5-year shelf life, like most respirators, 20% of the required target could be purchased over 5 years to achieve 100%. In year 6, product would begin to be replenished. This would provide additional product in an organization to share or use to address immediate surge needs; predictable costs for managing inventory; increases in the organization's normal/baseline order amounts, thus increasing the potential amount of product they receive during a response if products are prorated; and a predictable and higher production capacity in the supply chain to support larger regular purchases by organizations, which in turn creates increased artificial capacity during an actual event.
- *Improve domestic manufacturing surge capacity at the time of an event*—Federal emergency response partners need to work with the healthcare supply chain to better understand triggers for substantially increasing product manufacturing in response to an increased demand. This should include identifying ordering thresholds and business impact and risk, leading to a

better understanding of the factors that need to align to trigger manufacturing surge. Consideration should also be given to the ability to ramp up manufacturing capacity in the United States versus overseas during a response, given the potential for border closures or unanticipated delays in product importation to the United States. In addition, federal government investment in increasing production capacity, such as recent funding provided from HHS's Assistant Secretary for Preparedness and Response's Biomedical Advanced Research and Development Authority to an N95 respirator manufacturer to increase production capacity through development of the high-speed manufacturing line, needs to be considered.[40] Other government incentives that are not contractual in nature might also be explored to increase US surge, such as reducing the cost for licensing of facilities and products, expediting necessary government inspection of new lines, and other strategies to assist companies in overcoming barriers to new production development in the United States.

- *Share information and communicate regularly*—An efficient, low-burden mechanism for the federal government and private sector partners to share situational and supply information needs to be developed. Information sharing might assist in decision making (eg, releasing products from federal and state stockpiles, setting guidance, defining funding and product priorities) and provide information that may be needed to assist supply partners when demand is nationwide. During the 2009 H1N1 and the Ebola responses, federal guidance had a clear impact on PPE supply. Maximizing opportunities to share knowledge and details of the response (ie, information on guidance before it is released, what facilities might be most likely to see patients, estimated product volumes needed in each hospital, how to prioritize orders placed by the government that are competing for limited resources) would increase overall PPE preparedness. To minimize the confusion in the marketplace, clear product-specific information is needed to assist and provide N95 respirator purchasers and users with information about the available National Institute for Occupational Safety and Health (NIOSH)–approved devices. CDC worked with ISEA and the N95 respirator approval holders to create the NIOSH-approved Respirator Trusted-Source Information webpage.[41] NIOSH also created guidance for PPE selection option in the PPE-INFO database during the Ebola response to improve the product selection process by linking available products to standards and CDC recommendations.[38] Continuing to refine these tools will help end-users select the appropriate products during a response. Lastly, to improve the product selection process so that the PPE products most suited for the response are purchased, manufacturers should consider updating product labeling to clearly reflect product compliance with published standards.
- *Establish control banding best practices*—Control banding is a system for organizing qualitative and quantitative information and providing a decision logic to select appropriate control technologies that can be selected from a risk analysis that includes the severity of the hazard, frequency of exposure, and the likelihood of the exposure occurring. One approach to classifying exposures was published by OSHA in their "Guidance on Preparing Workplaces for an Influenza Pandemic," which classifies exposure into 4 risk categories.[42] It is important to develop national guidance for control banding for PPE selection and prioritization during public health emergencies. Structured guidance will facilitate respiratory protective device selection using available data, observations, and assumptions based on knowledge, past experience, and decision logic.

## Conclusion

The lessons learned from the 2009 H1N1 response and the Ebola response clearly identify areas where improvements in coordination are needed across the private and public sectors to address PPE use and supply strategies. The proposed strategies in this article aim to collectively increase readiness so that public health, health care, and commercial supply chain may work more cohesively as a system to reestablish the supply-demand equilibrium during a national emergency. The focus on preparedness over the past decade has been on products (eg, drugs, vaccines, devices, and diagnostic tools). Although these products are extremely important, recent events emphasize that the "system" for product manufacturing, distribution of supplies, and product use is critical to the success of a response. Building system capacity and private and public sector partnerships will help improve agility in the system, resulting in a more effective, organized emergency response.

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